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Koike et al.

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(54) **MASKING JIG AND ELECTROPLATING APPARATUS**

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C25D 7/00	(2006.01)
C25D 17/08	(2006.01)
C25D 7/04	(2006.01)

(52) **U.S. Cl.**

CPC ***C25D 5/022*** (2013.01); ***C25D 7/00*** (2013.01); ***C25D 7/04*** (2013.01); ***C25D 17/08*** (2013.01)

(58) **Field of Classification Search**

None

See application file for complete search history.

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(57) **ABSTRACT**

The masking jig includes a contact member and a support unit. The contact member includes a through-hole allowing for insertion of a rod-like piston rod, and a deformation part around the through-hole configured to get elastically deformed by insertion of a male thread of the piston rod into the through-hole and contact the outer peripheral end face of the piston rod. The support unit supports the contact member such that the contact member moves in a direction intersecting an axial direction of the piston rod.

20 Claims, 11 Drawing Sheets

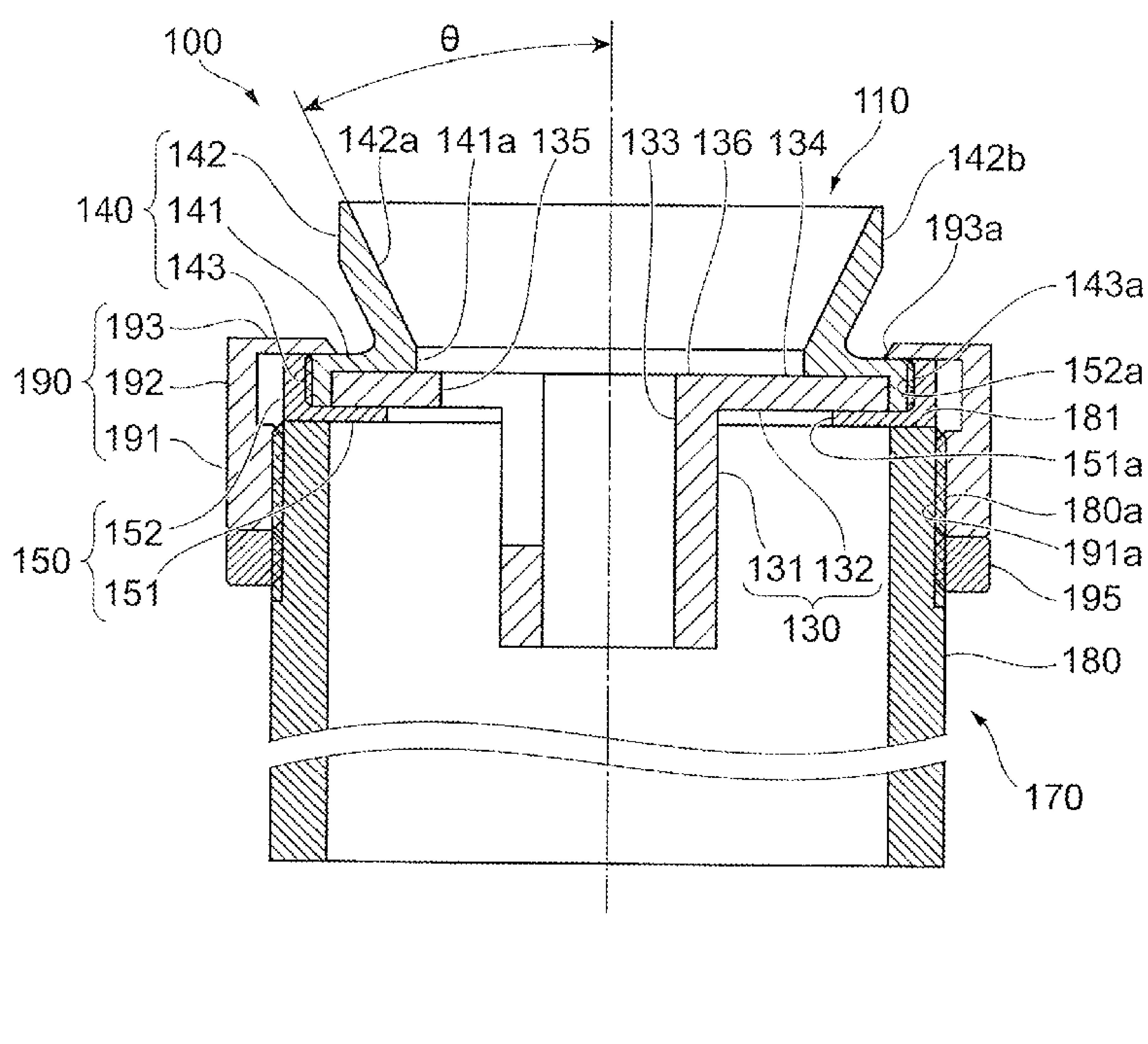
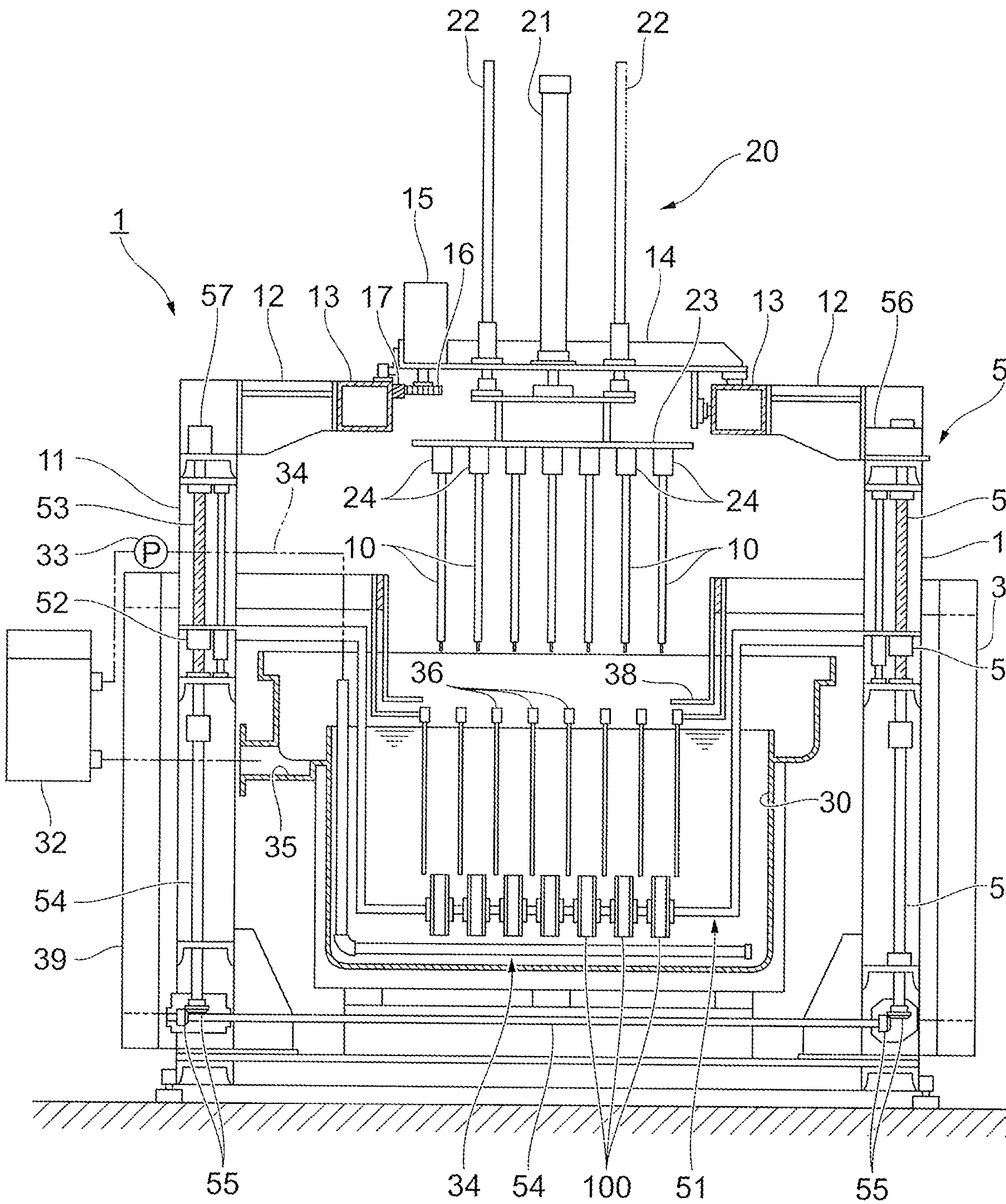


FIG.1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53
33
P
10
10
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35
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54
39
55
34
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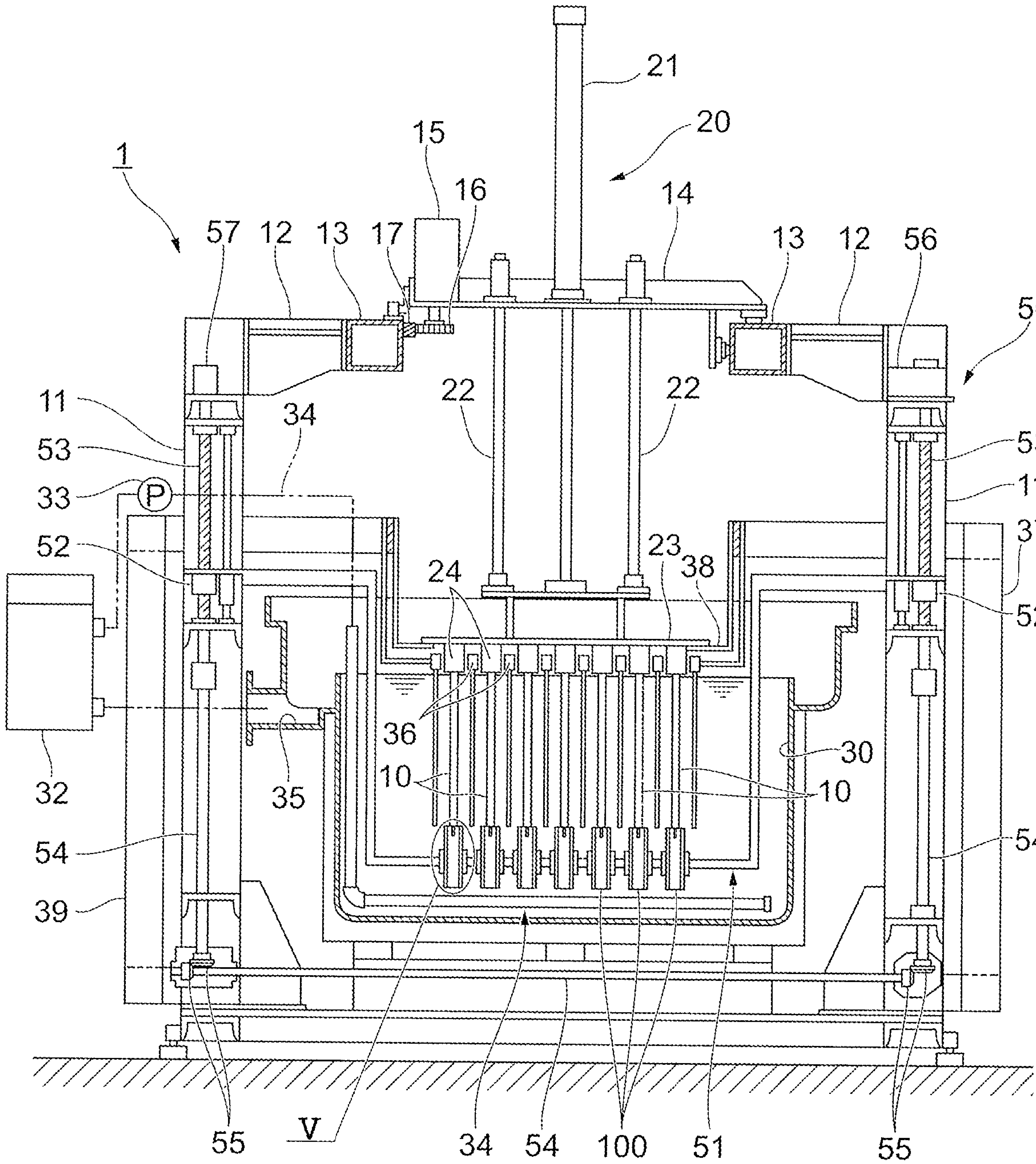
100
51
55

FIG.2



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P
11
37
52
23
38
24
52
36
30
32
10
10
35
54
54
39
55
V
34
54
100
51
55

FIG.3

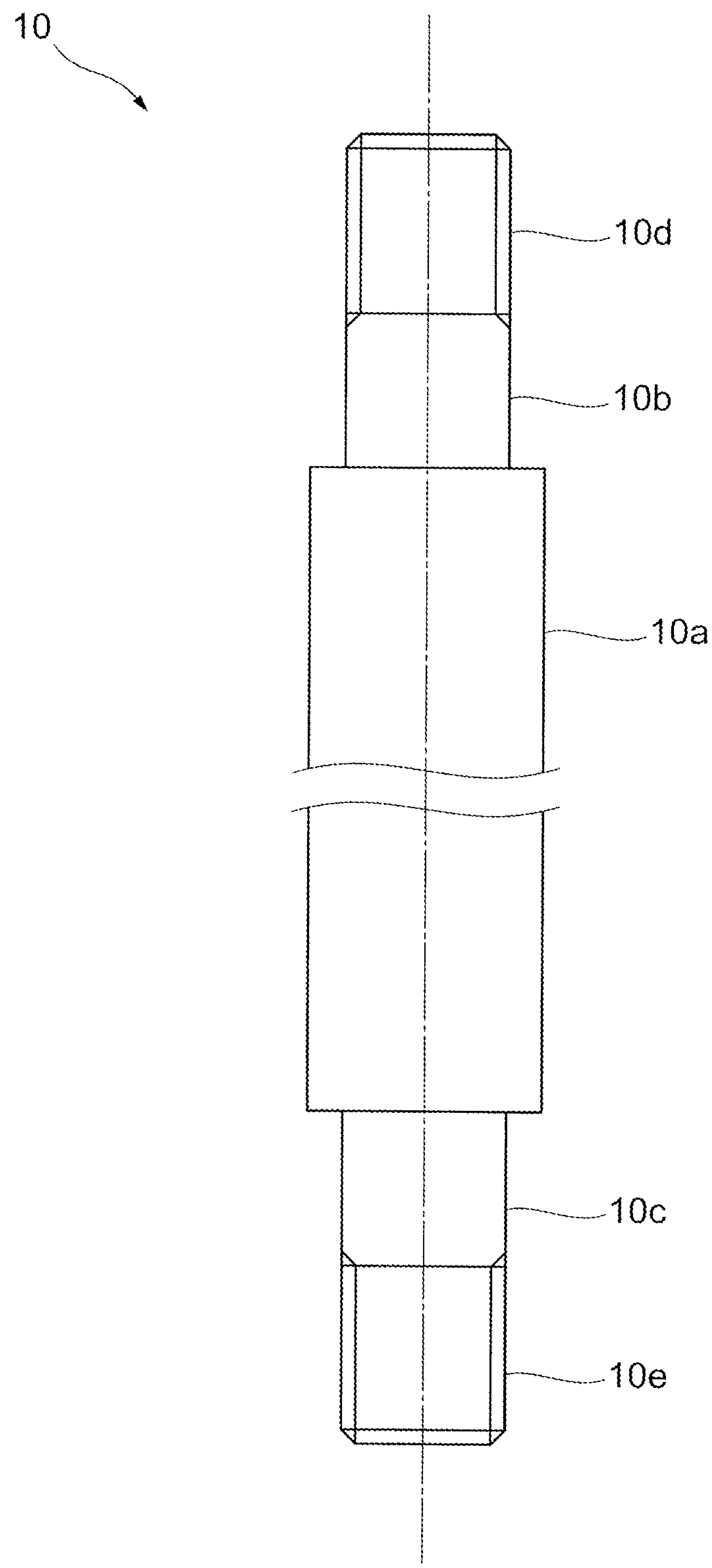
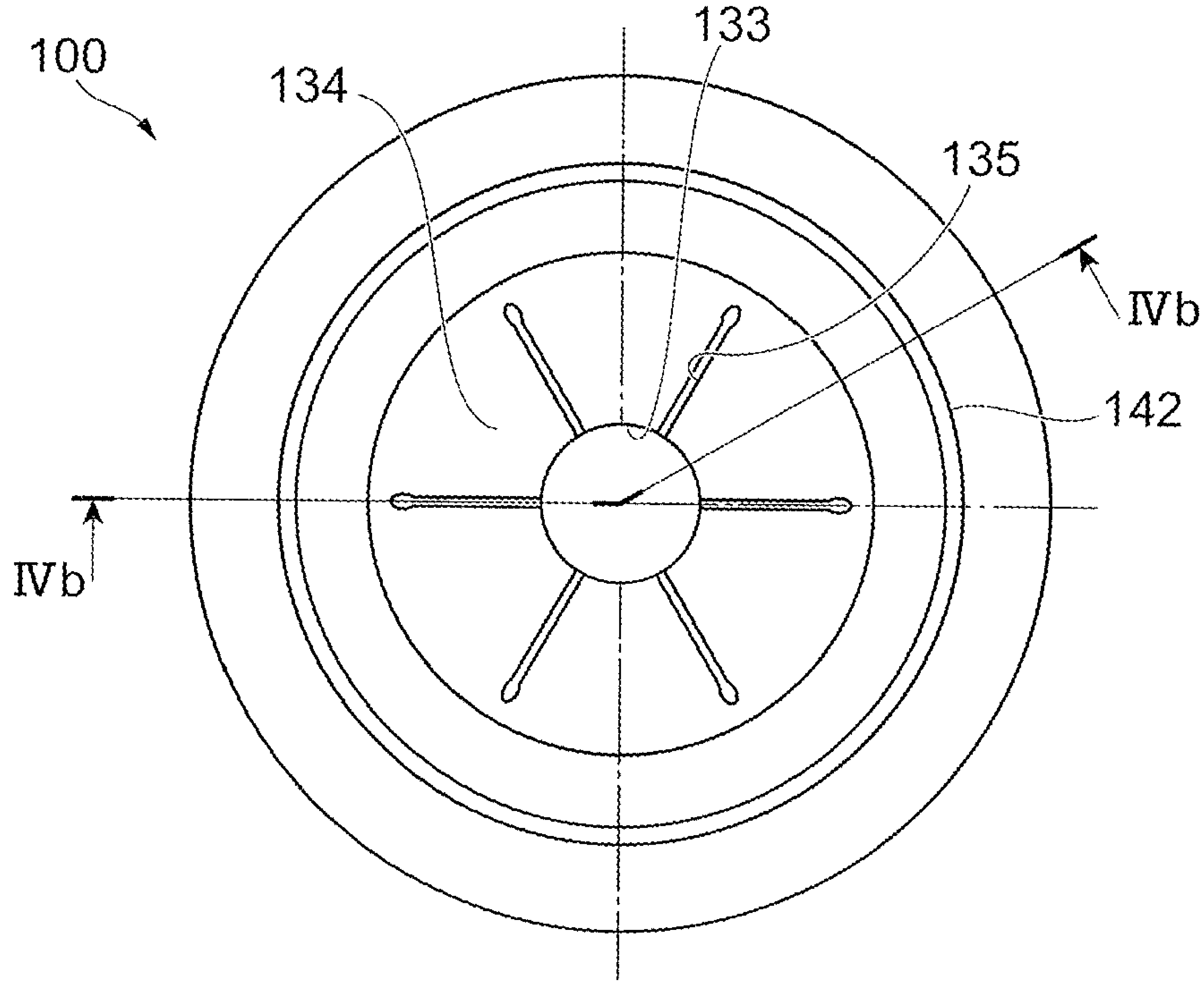


FIG.4A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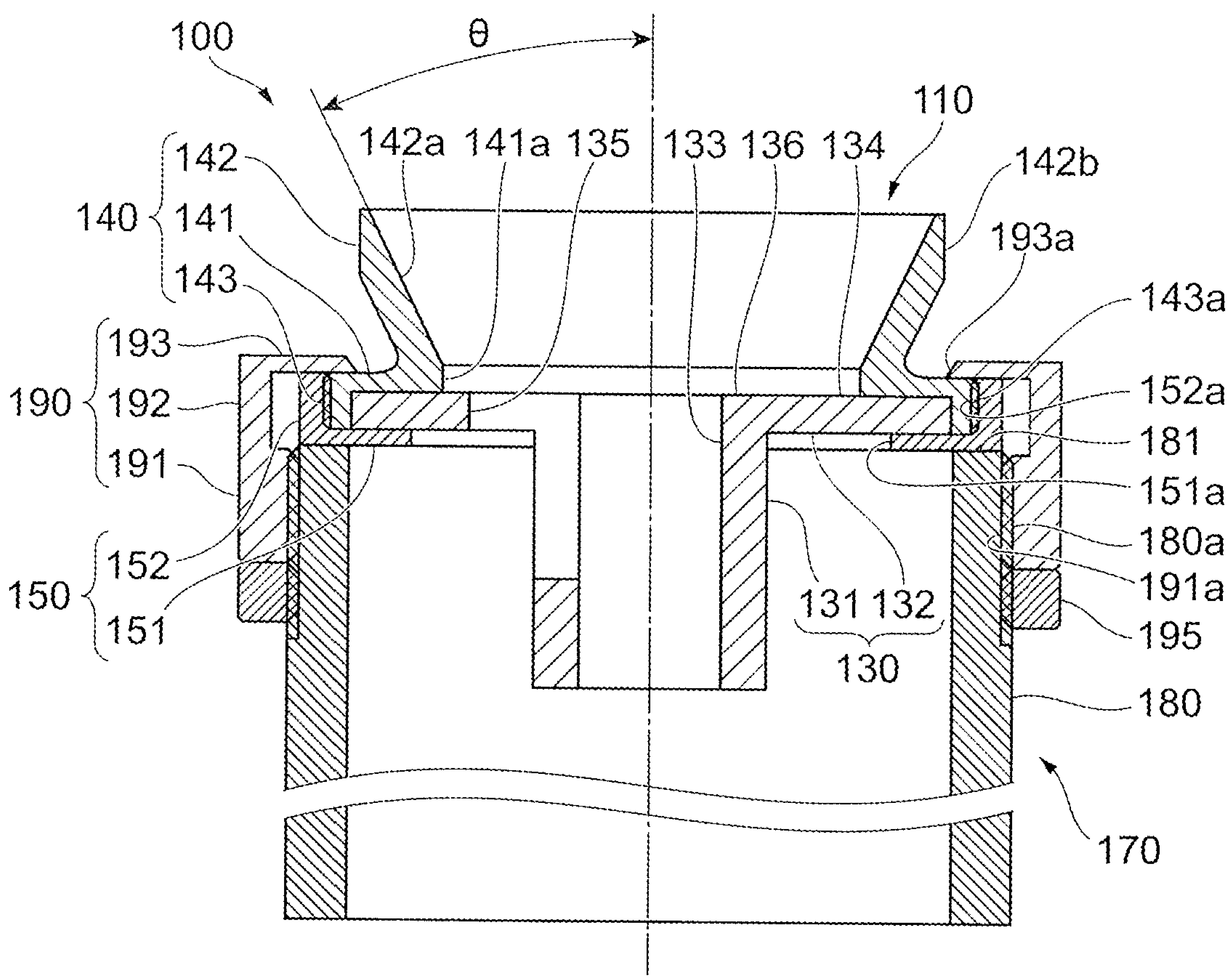
134
133
135
IVb
142
IVb

FIG.4B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θ
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142a 141a 135
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143
193a
143a
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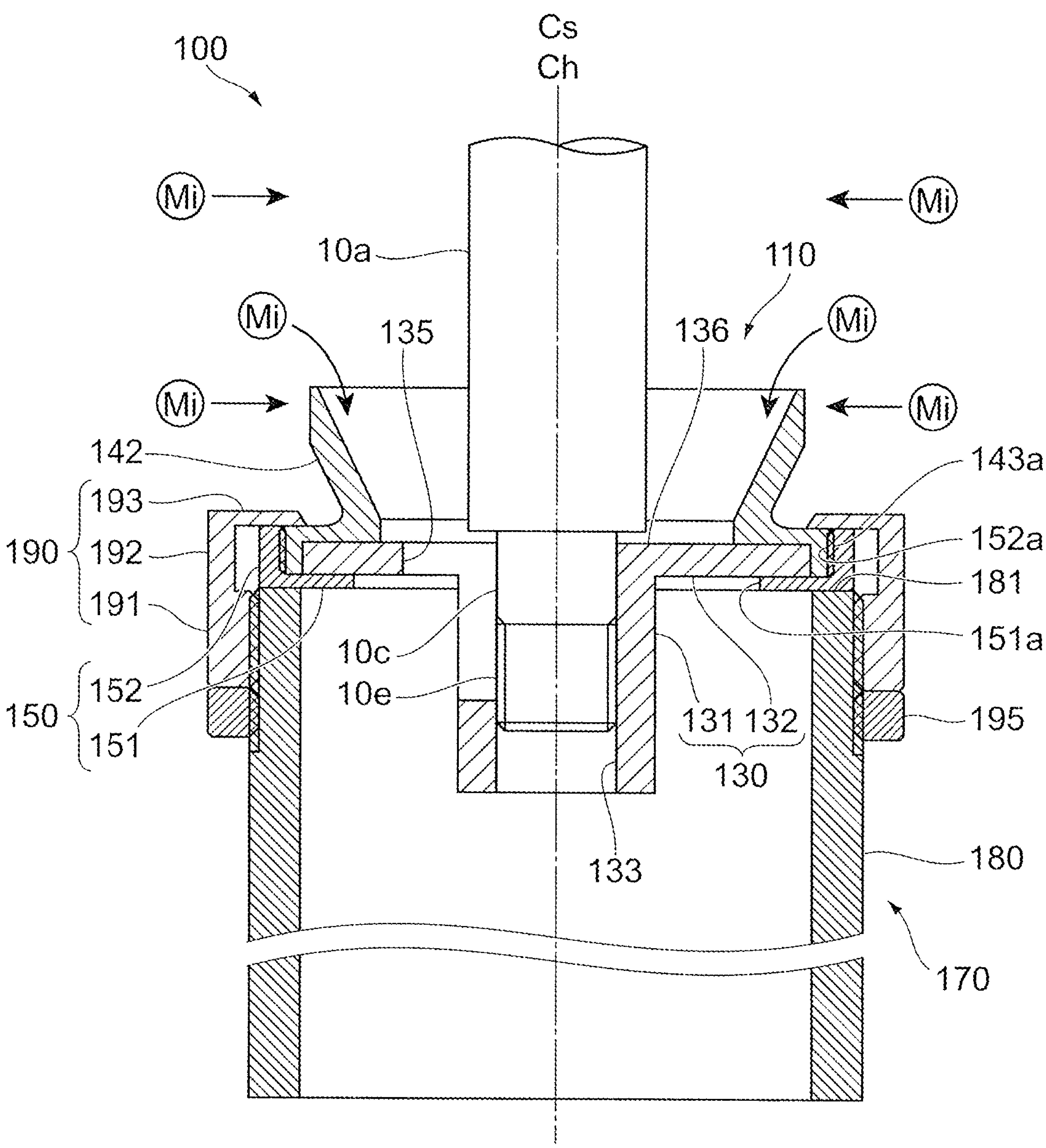
130
180
170

FIG.5



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Mi
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10c
10e
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150
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180
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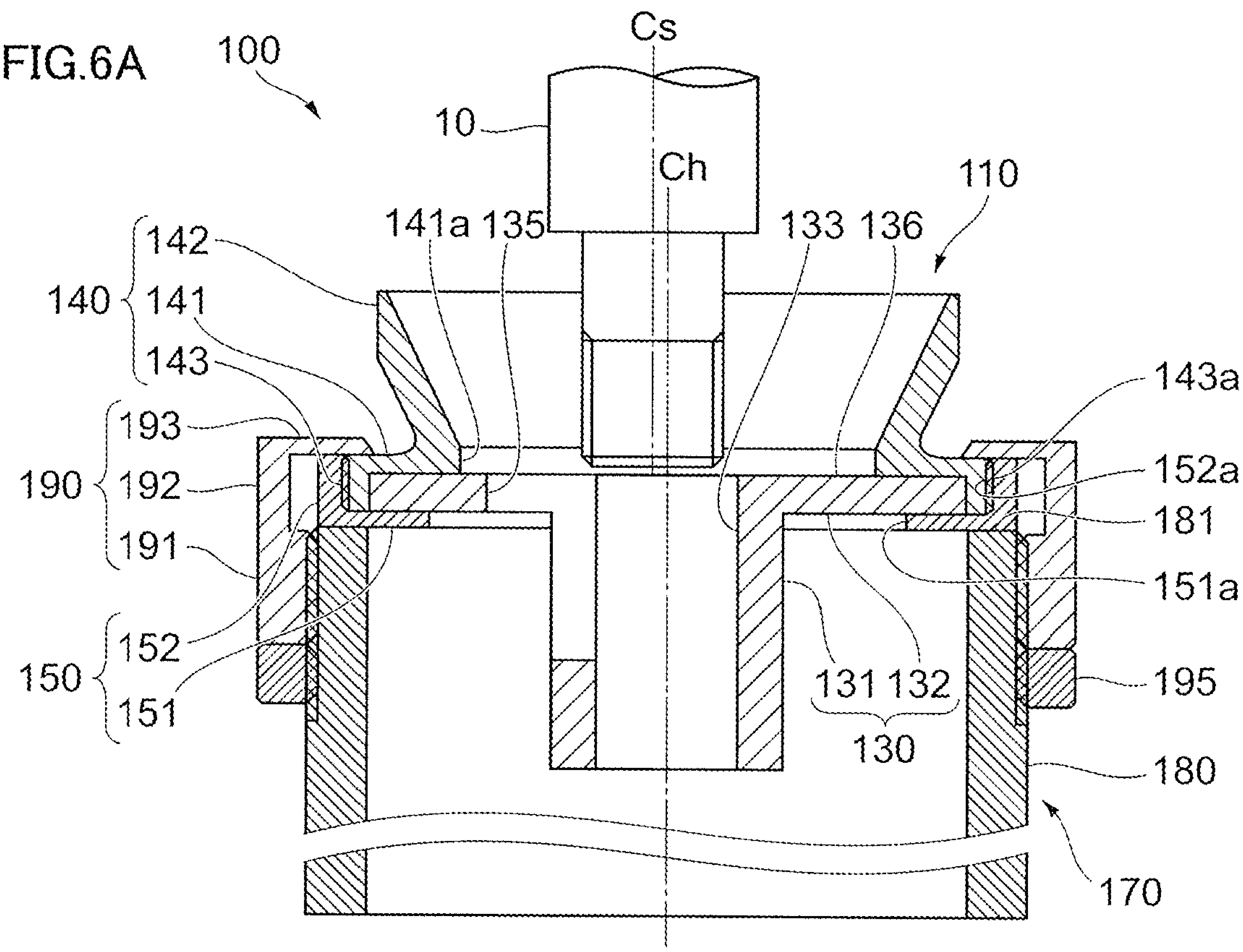
FIG.6A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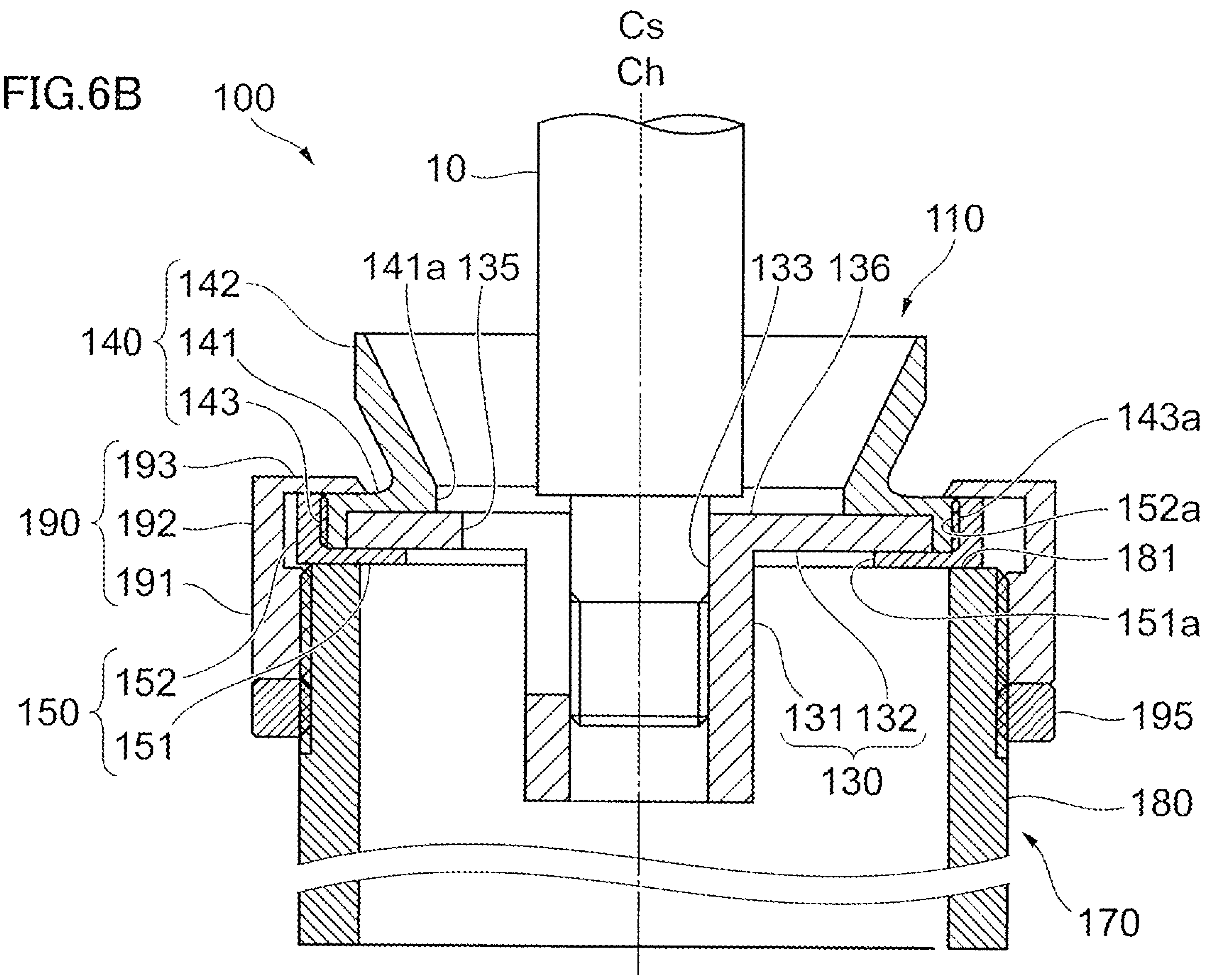
195
180
170

FIG.6B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195
180
170

FIG.7A

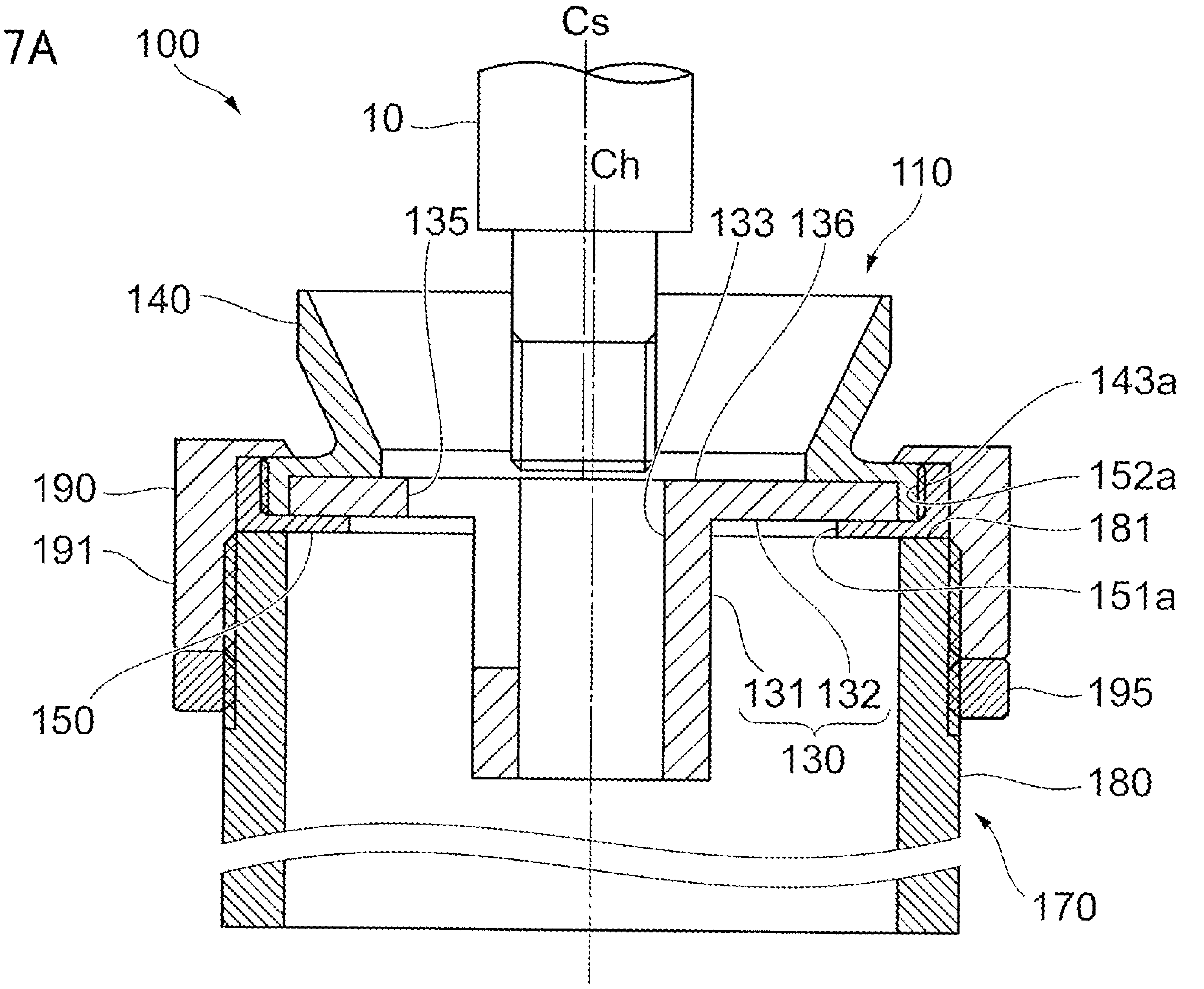
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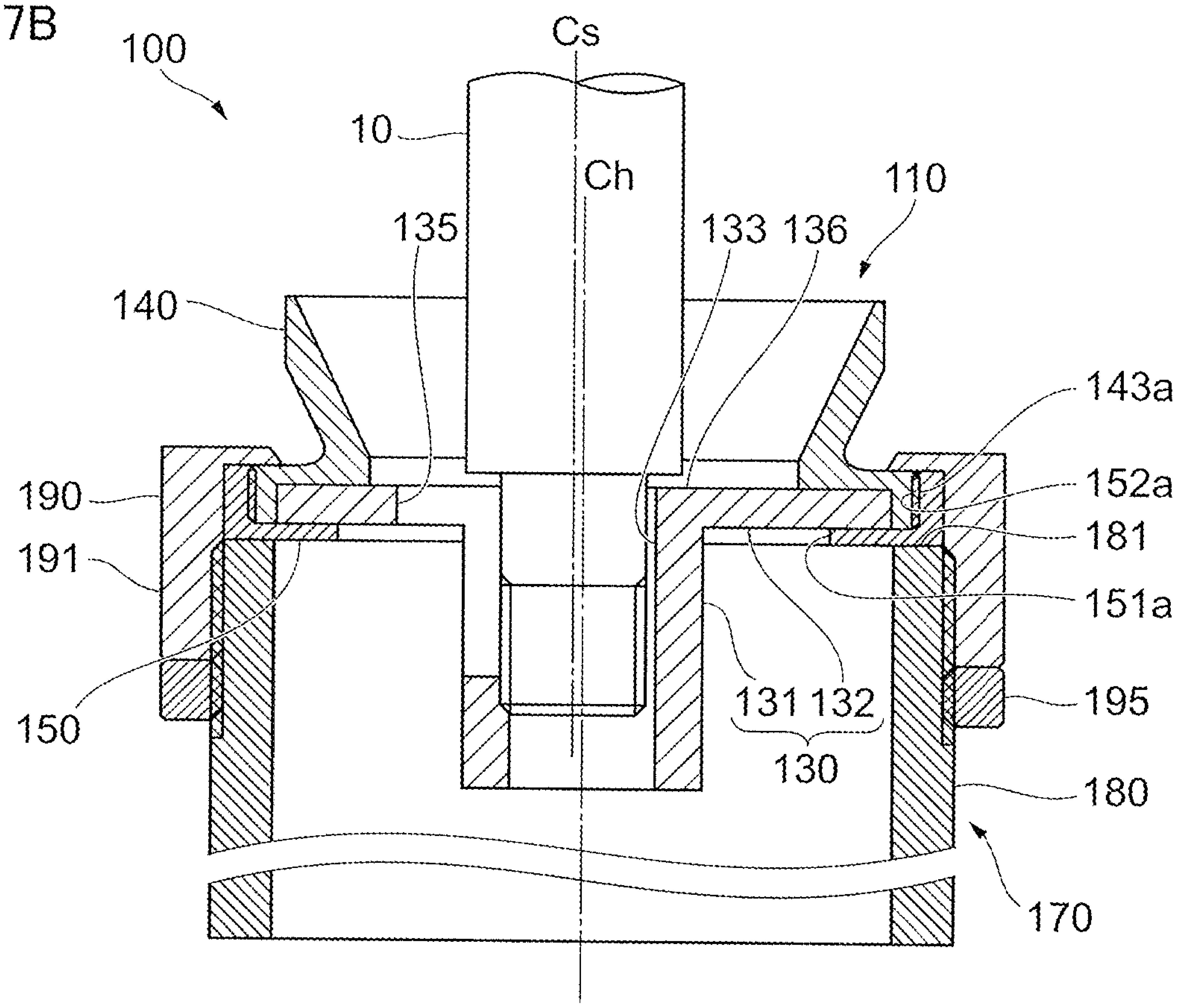
FIG.7B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151a
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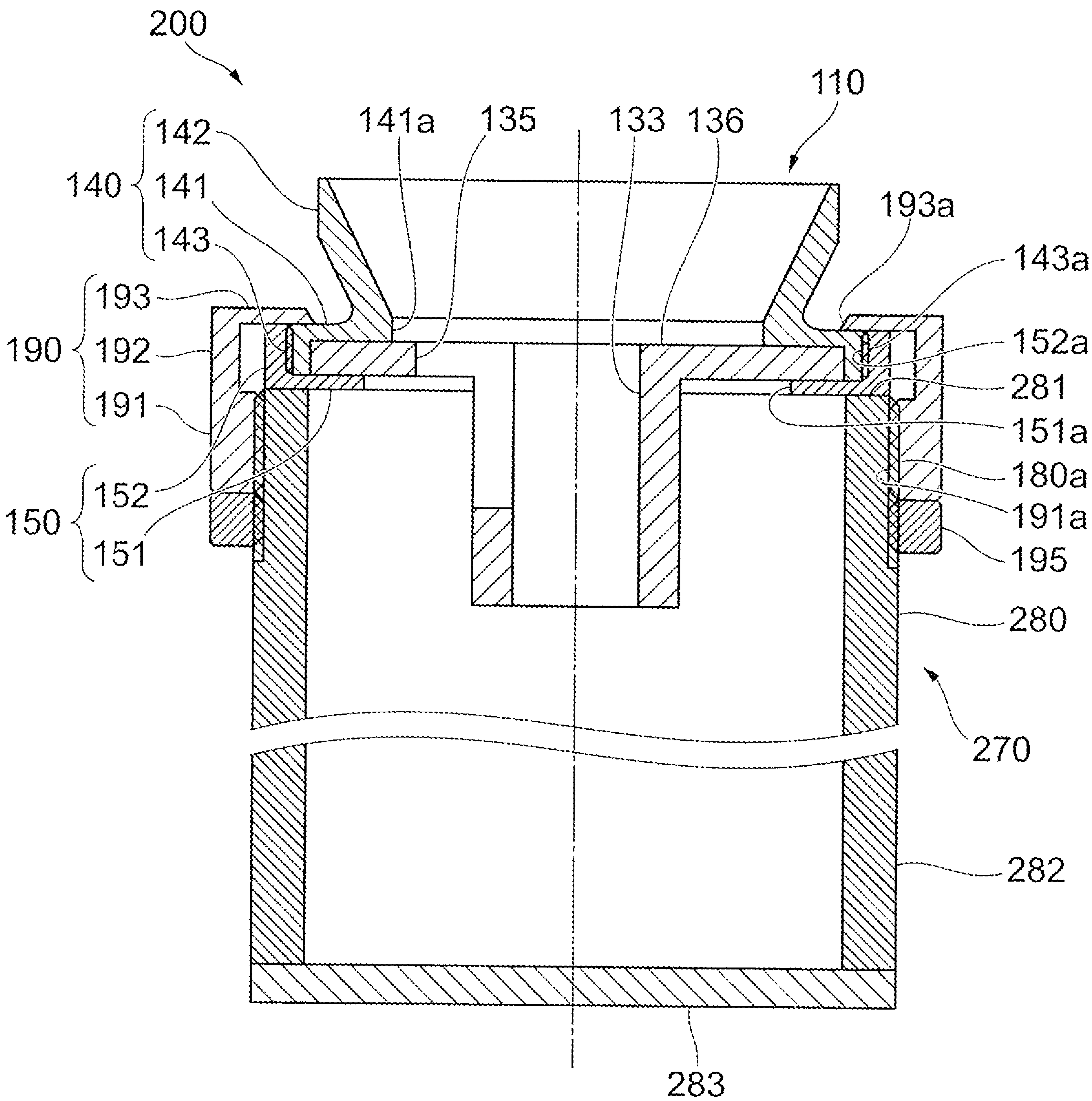
FIG.8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193a
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152a
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180a
191a
195
150
152
151
280
270
282
283

FIG.9A

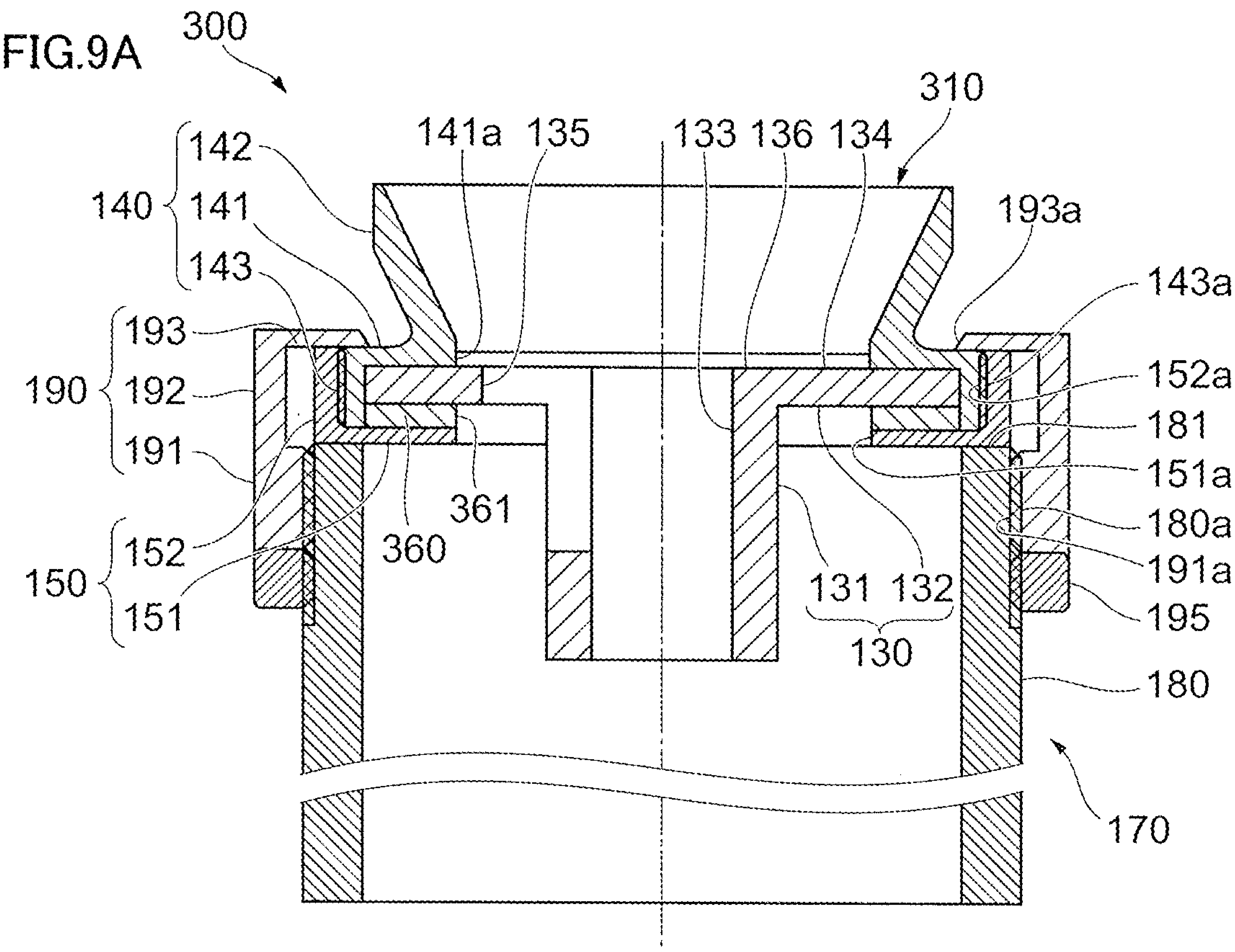
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FIG.9B

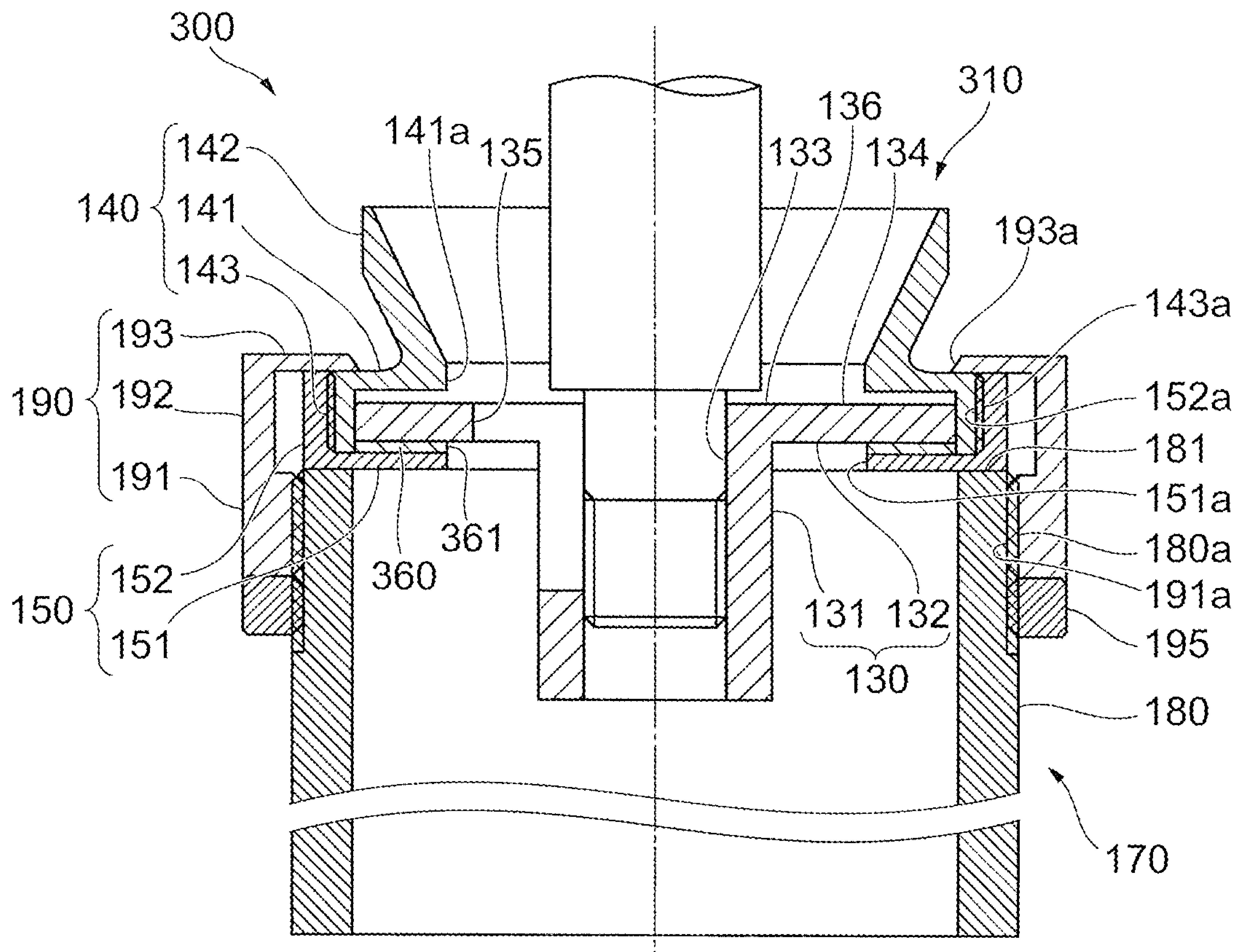
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FIG.10A

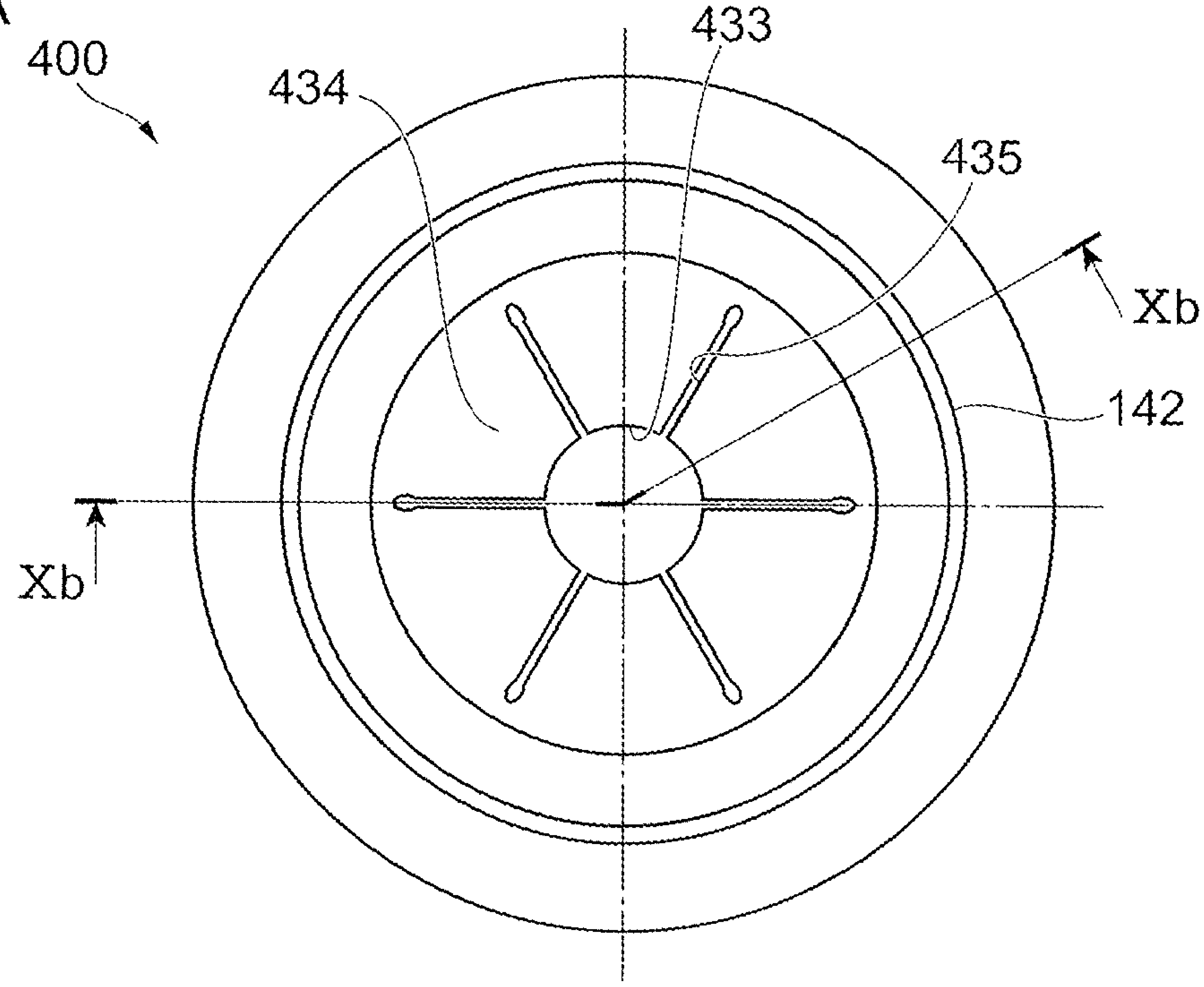


FIG.10B

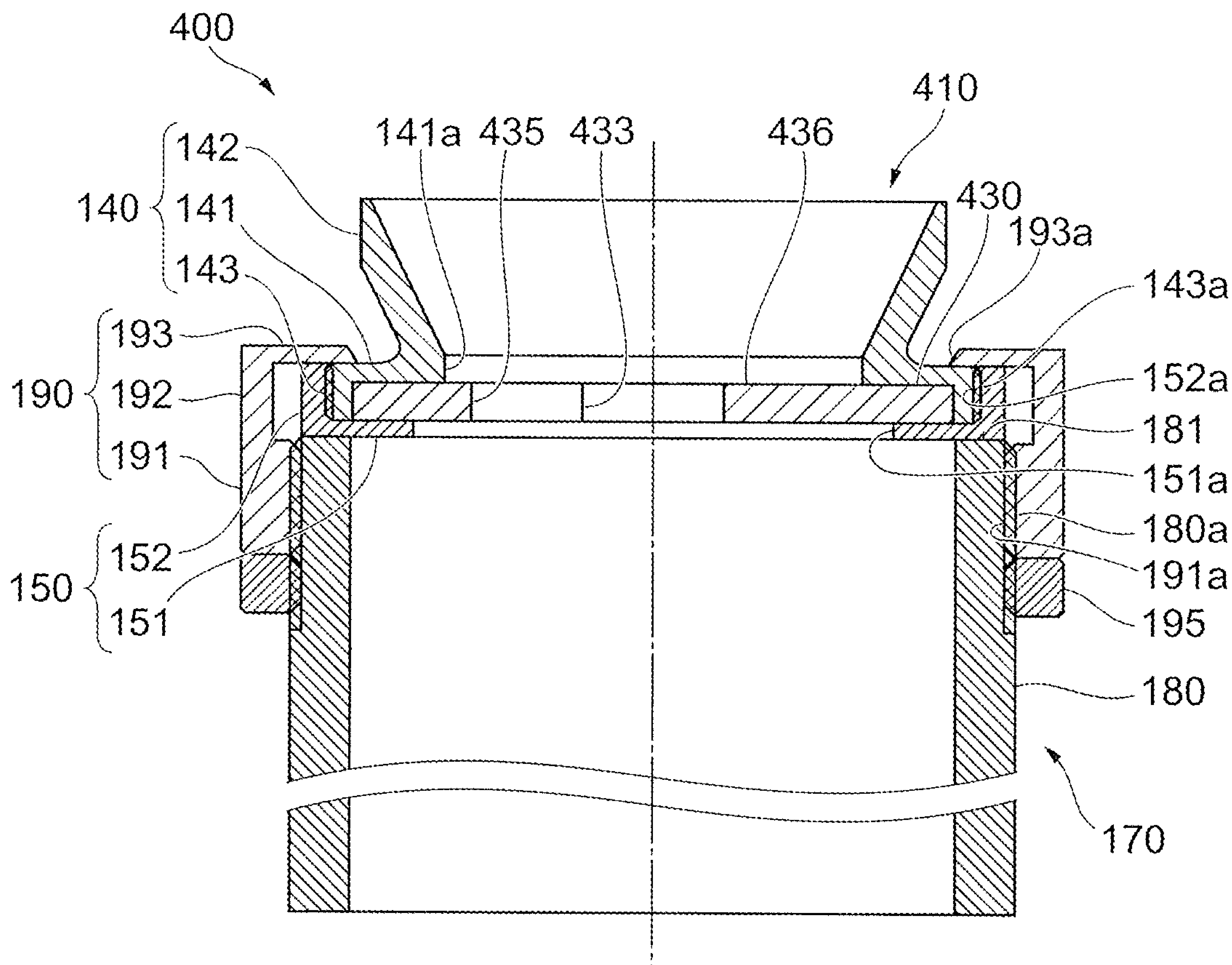
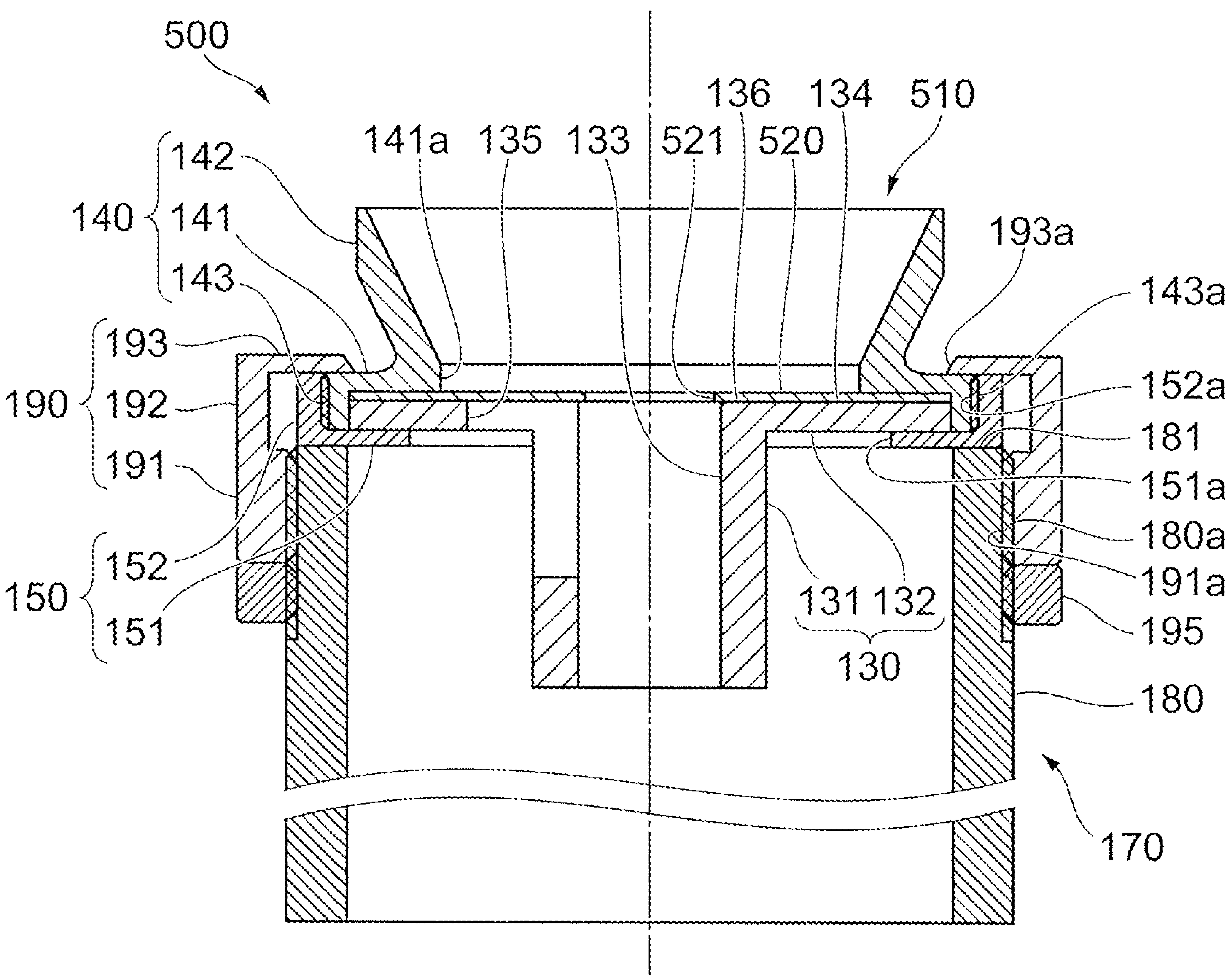


FIG.11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195
180
170
190
193
192
191
150
152
151
131
132
130

MASKING JIG AND ELECTROPLATING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of PCT application No. PCT/JP2017/030167 filed on Aug. 23, 2017, which claims the benefit of priority to Japanese Patent Application No. 2017-129233 filed on Jun. 30, 2017, the contents of both of which are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates to a masking jig and an electroplating apparatus.

BACKGROUND OF THE INVENTION

There has been proposed an electroplating apparatus including a masking jig to mask a lower part of a rod-like workpiece (a member to be plated).

For example, Japanese Patent Application Laid-Open Publication No. 09-013191 discloses an electroplating apparatus that immerses a rod-like workpiece suspended by a workpiece support mechanism into a plating tank having an anode and filled with a plating solution. In the plating tank, the electroplating apparatus includes a masking jig to mask a lower part of the workpiece, and the lower part of the workpiece is inserted into the masking jig in the solution and thus masked. To accommodate the lower part of the workpiece, the masking jig includes a recess or a through-hole each having a larger diameter than the outer diameter of the workpiece.

Technical Problem

For example if an axis of the rod-like member to be plated is misaligned with the recess or the through-hole of the masking jig before the member to be plated undergoes plating treatment to form a thin film of a plating substance (metal) on its certain part, a to-be-masked part of the plate member may also be plated (i.e., the thin film may be formed on the to-be-masked part).

The present invention aims to provide a masking jig and an electroplating apparatus each of which can prevent plating of the to-be-masked part.

SUMMARY OF THE INVENTION

Solution to Problem

With this object in view, the present invention is a masking jig including: a contact member including a through-hole and a deformation part around the through-hole, the through-hole allowing for insertion of a rod-like member to be plated, the deformation part being configured to get elastically deformed by insertion of a specific portion of the member to be plated into the through-hole and contact an outer peripheral end face of the member to be plated; and a support part configured to support the contact member such that the contact member moves in a direction intersecting an axial direction of the member to be plated.

From another standpoint, the present invention is an electroplating apparatus including: a plating tank storing a plating solution containing a plating substance; a holding part configured to hold a rod-like member to be plated; and a masking jig placed within the plating tank, the masking jig being configured to mask a specific portion of the member to be plated, wherein the masking jig includes: a contact member including a through-hole and a deformation part around the through-hole, the through-hole allowing for insertion of the member to be plated, the deformation part being configured to get elastically deformed by insertion of the specific portion into the through-hole and contact an outer peripheral end face of the member to be plated; and a support part configured to support the contact member such that the contact member moves in a direction intersecting an axial direction of the member to be plated.

Advantageous Effects of Invention

The present invention allows to align the axis of the member to be plated with the center of the masking jig, preventing plating of the to-be-masked part.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** depicts a schematic configuration of an electroplating apparatus of the embodiments.

FIG. **2** depicts the electroplating apparatus during plating treatment.

FIG. **3** is a schematic view of a piston rod as an example of the member to be plated.

FIGS. **4**A and **4**B depict a schematic configuration of a masking jig of the first embodiment.

FIG. **5** depicts the masking jig of the first embodiment when a piston rod is inserted in it.

FIG. **6**A depicts the masking jig of the first embodiment before the piston rod is inserted in it. FIG. **6**B depicts the masking jig of the first embodiment when the piston rod is inserted in it.

FIG. **7**A depicts a masking jig of a comparative example before the piston rod is inserted into it. FIG. **7**B depicts the masking jig of the comparative example when the piston rod is inserted in it.

FIG. **8** depicts a schematic configuration of a masking jig of the second embodiment.

FIG. **9**A depicts a schematic configuration of a masking jig of the third embodiment. FIG. **9**B depicts the masking jig **300** of the third embodiment when the piston rod **10** is inserted in it.

FIGS. **10**A and **10**B depict a schematic configuration of a masking jig of the fourth embodiment.

FIG. **11** depicts a schematic configuration of a masking jig of the fifth embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Embodiments of the present invention will be described below with reference to the attached drawings.

FIG. **1** depicts a schematic configuration of an electroplating apparatus **1** of the embodiments.

FIG. **2** depicts the electroplating apparatus **1** during plating treatment.

The electroplating apparatus **1** includes a holding mechanism **20** and a plating tank **30**. The holding mechanism **20**, which is an example of a holding unit, holds a piston rod **10**, which is an example of the rod-like member to be plated. The plating tank **30** stores a plating solution containing a plating substance. The electroplating apparatus **1** holds multiple piston rods **10** with the holding mechanism **20**, and subjects the multiple piston rods **10** to plating treatment by immersing them in the plating tank **30** located below.

The electroplating apparatus **1** includes: multiple pillars **11** extending in a vertical direction; a horizontal plate **12** laid over the multiple pillars **11**; two rails **13** extending in a forward and backward direction (direction perpendicular to the plane of the figure); and a mobile carriage **14** running on the two rails **13**.

The electroplating apparatus **1** further includes: a motor **15** mounted on the mobile carriage **14**; a pinion **16** attached to an output shaft of the motor **15**; and a rack **17** extending in the forward and backward direction and forming a pinion-rack mechanism with the pinion **16**. Driving of the motor **15** causes the mobile carriage **14** to move in the forward and backward direction.

The holding mechanism **20** includes: an elevation cylinder **21** moving up and down the piston rods **10**; two guides **22** assisting the elevation cylinder **21** in moving up and down the piston rods **10**; and an elevation plate **23** attached to lower ends of the elevation cylinder **21** and the two guides **22**. The holding mechanism **20** further includes multiple holding sockets **24** attached to the elevation plate **23** and holdings the respective piston rods **10**. The multiple holding sockets **24** move up and down with the elevation plate **23** by extension and contraction of the elevation cylinder **21**.

The electroplating apparatus **1** further includes: a tank **32** storing a plating solution; a pump **33**; a supply pipe **34** to supply the plating solution stored in the tank **32** to the plating tank **30**; and a return pipe **35** to return the plating solution in the plating tank **30** to the tank **32**.

The electroplating apparatus **1** further includes: an anode **36** for electroplating; an anode-side bus bar **37**; a cathode receiver **38**; and a cathode-side bus bar **39**.

The electroplating apparatus **1** further includes: a masking jig **100** disposed in the plating tank **30** to mask particular parts of the piston rods **10**; and an elevation mechanism **50** holding the masking jig **100** and moving up and down with the masking jig **100**.

The masking jig **100** will be described in detail later.

The elevation mechanism **50** includes: a substantially U-shaped frame **51** holding the masking jig **100**; multiple nut members **52** supporting both ends of the frame **51**; screws **53** moving up and down the respective nut members **52**; and a transmission rod **54** and bevel gears **55** to rotate the screws **53**. The elevation mechanism **50** further includes a motor **56** coupled with one of the screws **53**, and a rotation detector **57** coupled with the other of the screws **53**.

The above configured electroplating apparatus **1** has the capability to adjust the height of the masking jig **100** according to the length of members to undergo the plating treatment (the piston rods **10** in the present embodiments) or parts to be masked. The motor **15** is driven to move the members to be plated (the piston rods **10**) to a position above the plating tank **30**, and then the elevation cylinder **21** is driven to move down the members to be plated from that position. The elevation plate **23** is thus placed on the cathode receiver **38**. Then, a predetermined voltage is applied between the anode **36** and the members to be plated (the piston rods **10**) via the anode-side bus bar **37** and the cathode-side bus bar **39**. This causes metal ion (e.g., Cr ion), which is an example of the plating substance in the plating solution, to move toward the members to be plated (the piston rods **10**) on the cathode side, resulting in the metal being deposited by reduction.

(Piston Rod and Masking Jig)

FIG. **3** is a schematic view of the piston rod **10** as an example of the member to be plated. The figure illustrates the piston rod **10** in the same orientation as FIG. **1**.

FIGS. **4**A and **4**B depict a schematic configuration of the masking jig **100** of the first embodiment. The masking jig **100** is preferable for subjecting the piston rod **10** to plating treatment.

(Piston Rod)

The piston rod **10** is a component used for suspension of a vehicle. The piston rod **10** holds, at one end thereof, a piston located within a cylinder. The other end of the piston rod **10** exposes to the outside of the cylinder. For example to avoid the situation where the part of the piston rod **10** exposed to the outside of the cylinder is worn by sliding contact with an oil seal to seal the cylinder, hard chromium plating is performed on that part in sliding contact with the oil seal.

The piston rod **10** consists of multiple columnar parts each having a different outer diameter, namely a central shaft part **10***a* with the largest outer diameter, an upper shaft part **10***b* above the central shaft part **10***a*, and a lower shaft part **10***c* below the central shaft part **10***a*. A male thread **10***d* is formed on the outer periphery at the upper end of the upper shaft part **10***b*, and a male thread **10***e* is formed on the outer periphery at the lower end of the lower shaft part **10***c*. The central shaft part **10***a* contacts the oil seal, meaning that the central shaft part **10***a* is a part to be plated by the electroplating apparatus **1** (i.e., the part on which a metal thin film is to be formed). The male threads **10***d*, **10***e* are the parts to be fastened with nuts, and thus they are not to be plated (i.e., no metal thin film is formed on them). The upper shaft part **10***b* is held by the holding socket **24** of the holding mechanism **20**, and the male thread **10***e* is masked by the masking jig **100**.

(Masking Jig)

First Embodiment

The masking jig **100** of the first embodiment includes a prevention unit **110** and a support unit **170**. The prevention unit **110** prevents metal ion, which is an example of the plating substance, from moving toward the male thread **10***e*, which is an example of the specific part of the rod-like piston rod **10**. As an example of the support part, the support unit **170** supports the prevention unit **110** such that the prevention unit **110** can move in a direction intersecting the axis of the piston rod **10**.

[Prevention Unit]

The prevention unit **110** includes a contact member **130** that contacts the outer periphery of the lower shaft part **10***c* of the piston rod **10** to thereby prevent the metal ion from moving toward the male thread **10***e*. The prevention unit **110** further includes a prevention member **140** that surrounds the lower end of the central shaft part **10***a*, which is located above the male thread **10***e* of the piston rod **10**, to thereby prevent the metal ion from moving toward the male thread **10***e*. The prevention unit **110** further includes a holding member **150** that holds the contact member **120** and the prevention member **140**.

The contact member **130** includes a cylindrical part **131** surrounding the lower shaft part **10***c* (the male thread **10***e*) of the piston rod **10**, and a flange **132** at the upper end of the cylindrical part **131**. The contact member **130** is an elastic body, such as rubber. For example, the contact member **130** is molded of thermoplastic fluoropolymer, such as polyvinylidene fluoride (PVDF).

The inner diameter of the cylindrical part **131** is equal to the outer diameter of the lower shaft part **10***c* of the piston rod **10**. The length of the cylindrical part **131** in the centerline direction is longer than that of the lower shaft part **10***c* of the piston rod **10**. Accordingly, the lower shaft part **10***c* of the piston rod **10** is situated inside the contact member **130**. The inside of the cylindrical part **131** of the contact member **130** functions as a through-hole **133** that allows for insertion of the lower shaft part **10***c* of the piston rod **10**.

Around the through-hole **133** allowing for insertion of the lower shaft part **10***c* of the piston rod **10**, the contact member **130** includes a deformation part **134**. The deformation part **134** is elastically deformed by insertion of the male thread **10***e* into the through-hole **133** and contacts the outer peripheral end face of the piston rod **10**. The deformation part **134** consists of upper and middle sections of the cylindrical part **131** and a central section of the flange **132**. The deformation part **134** includes radial slits **135** dividing the deformation part **134** into multiple sections. That is, the contact member **130** includes multiple separate contact pieces **136**, and the slits **135** are formed so that the contact pieces **136** do not contact each other in a state where the lower shaft part **10***c* of the piston rod **10** is not inserted.

In the masking jig **100**, the centerline direction of the cylindrical parts and members including the cylindrical part **131** coincides with the axial direction of the piston rod **10**.

The prevention member **140** includes: a round and planar base part **141** including a through-hole **141***a* at the center thereof; an inclined part **142** extending upward from the inner peripheral end of the base part **141** in a direction obliquely intersecting the axial direction; and a cylindrical part **143** extending downward in the axial direction from the outer peripheral end of the base part **141**.

The hole diameter of the through-hole **141***a* of the base part **141** is larger than the outer diameter of the central shaft part **10***a* of the piston rod **10**. The outer diameter of the base part **141** is larger than the outer diameter of the contact member **130**.

The inclined part **142** is formed such that a distance between an inner surface **142***a* and an outer surface of the central shaft part **10***a* of the piston rod **10** gradually narrows from the top to the bottom. In other words, the inclined part **142** is inclined relative to the axis such that a distance between the inclined part **142** and the central shaft part **10***a*, which is an example of the specific portion, gradually narrows toward the contact member **130**. For example, the inclination angle θ of the inclined part **142** relative to the axis is less than 45 degrees. An upper outer surface **142***b* of the inclined part **142** has a constant outer diameter along a predetermined length so that the upper outer surface **142***b* is parallel to the axis. A lower outer surface of the inclined part **142** below the upper outer surface **142***b* is molded to have an outer diameter gradually narrowing from the top to the bottom, in such a manner to ensure that the wall thickness of the lower outer surface remains substantially constant.

The inner diameter of the cylindrical part **143** is larger than the outer diameter of the flange **132** of the contact member **130**, and the size of the cylindrical part **143** in the axial direction is larger than that of the flange **132** of the contact member **130**. The cylindrical part **143** includes on its outer surface a male thread **143***a* that is fastened to a female thread **152***a* of the holding member **150**.

The prevention member **140** is made of metal or resin, for example.

The holding member **150** includes a round and planar disk part **151** having a through-hole **151***a* at the center thereof, and a cylindrical part **152** extending upward in the axial direction from the outer peripheral end of the disk part **151**.

The hole diameter of the through-hole **151***a* of the disk part **151** is larger than the outer diameter of the cylindrical part **131** of the contact member **130**, and smaller than the outer diameter of the flange **132** of the contact member **130**. the outer diameter of the disk part **151** is larger than that of the flange **132** of the contact member **130**.

The cylindrical part **152** includes on its inner surface the female thread **152***a* fastened to the male thread **143***a* on the outer surface of the cylindrical part **143** of the prevention member **140**.

The holding member **150** is made of metal or resin, for example.

With the contact member **130** interposed between the disk part **151** of the holding member **150** and the base part **141** of the prevention member **140**, the male thread **143***a* of the prevention member **140** is fastened to the female thread **152***a* of the holding member **150**. These components are thus integrated to form the above configured prevention unit **110**.

[Support Unit]

The support unit **170** includes: a base **180** on which the prevention unit **110** rests; a restricting member **190** to restrict movement of the prevention unit **110** in the axial direction by holding the prevention unit **110** between the base **180** and the restricting member **190**; and a lock nut **195** to restrict movement of the restricting member **190**.

The base **180** is a cylindrical member and includes an upper end face **181** perpendicular to the axial direction. The inner diameter of the base **180** is larger than the outer diameter of the cylindrical part **131** of the surrounding member **130** of the prevention unit **110**, and the length of the base **180** in the axial direction is longer than that of the cylindrical part **131** of the surrounding member **130**. The outer diameter of the base **180** is equal to or larger than the outer diameter of the holding member **150** of the prevention unit **110**. On an upper outer surface of the base **180**, there is a male thread **180***a* fastened to a female thread **191***a* of the restricting member **190**.

The base **180** is made of metal or resin, for example.

The restricting member **190** includes two cylindrical parts having the same outer diameter and different inner diameters, namely a first cylindrical part **191** and a second cylindrical part **192**, and a protrusion **193** protruding from the upper end of the second cylindrical part **192** to the inside (to the center).

The restricting member **190** is made of metal or resin, for example.

The first cylindrical part **191** includes on its inner surface the female thread **191***a* fastened to the male thread **180***a* on the outer surface of the base **180**.

The inner diameter of the second cylindrical part **192** is larger than that of the first cylindrical part **191**. The size of the second cylindrical part **192** in the axial direction is larger than that of the holding member **150** of the prevention unit **110**.

The protrusion **193** is a round and planar part including a through-hole **193***a* at the center thereof. The hole diameter of the through-hole **193***a* is smaller than the inner diameter of the cylindrical part **143** of the prevention member **140** of the prevention unit **110**. The hole diameter of the through-hole **193***a* is larger than the outer diameter of the upper outer surface **142***b*, which is the largest outer diameter in the inclined part **142** of the prevention member **140**.

With the above configuration of the support unit **170**, the lower end face of the holding member **150** of the prevention unit **110** (the bottom face of the disk part **151**) is placed on the upper end face **181** of the base **180**, and in that state the restricting member **190** is fitted to the base **180**. At this time, the inclined part **142** of the prevention member **140** of the prevention unit **110** is passed through the through-hole **193***a* of the protrusion **193** of the restricting member **190**. Then, the female thread **191***a* of the restricting member **190** is fastened to the male thread **180***a* of the base **180** to movably support the prevention unit **110**. Downward movement of the restricting member **190** is restricted by the lock nut **195** fastened to the male thread **180***a* of the base **180**. The lock nut **195** is positioned such that a gap between the upper end face **181** of the base **180** and the protrusion **193** of the restricting member **190** is larger than the size of the prevention unit **110**, which is to be held between the upper end face **181** of the base **180** and the protrusion **193** of the restricting member **190**.

The inner diameter of the second cylindrical part **192** of the restricting member **190** is larger than the inner diameter of the first cylindrical part **191**, and also larger than the outer diameter of the holding member **150** of the prevention unit **110**. This forms a gap between the inner surface of the second cylindrical part **192** and the outer surface of the holding member **150** of the prevention unit **110**. This means that the prevention unit **110** can move in the direction perpendicular to the axial direction until the outer surface of the holding member **150** contacts the inner surface of the second cylindrical part **192** of the restricting member **190**.

FIG. **5** depicts the masking jig **100** of the first embodiment when the piston rod **10** is inserted in it. That is, FIG. **5** is also an enlarged cross-sectional view of the part V in FIG. **2**.

In the electroplating apparatus **1**, when a predetermined voltage is applied between the anode **36** and the piston rod **10** via the anode-side bus bar **37** and the cathode-side bus bar **39**, the metal ion Mi in the plating solution moves toward the piston rod **10** on the cathode side, resulting in the metal being deposited by reduction.

Meanwhile, the gap between the inner surface **142***a* of the inclined part **142** of the prevention member **140** and the outer surface of the central shaft part **10***a* of the piston rod **10** gradually narrows from the top to the bottom. For this reason, the amount of metal ion Mi reaching the outer surface of the central shaft part **10***a* gradually reduces toward the lowest end of the central shaft part **10***a*. Also, the inner diameter of the cylindrical part **131** of the contact member **130** of the prevention unit **110** (the hole diameter of the through-hole **133**) is equal to the outer diameter of the lower shaft part **10***c* of the piston rod **10**. Accordingly, when the lower shaft part **10***c* of the piston rod **10** is inserted in the through-hole **133**, the inner surface of the cylindrical part **131** of the contact member **130** is in contact with the outer surface of the lower shaft part **10***c* of the piston rod **10**. This allows the contact member **130** to block the metal ion Mi from moving toward the male thread **10***e* by going through the inner surface of the cylindrical part **131** of the contact member **130** and the outer surface of the lower shaft part **10***c* from above the contact member **130**. Moreover, the cylindrical part **131** of the contact member **130** surrounds the male thread **10***e*. This prevents the metal ion Mi from moving toward the male thread **10***e* through between the outer surface of the cylindrical part **131**, which is the outer side of the cylindrical part **131**, and the inner surface of the base **180**. These can prevent formation of a metal thin film (reductive deposition of metal) on the male thread **10***e* of the piston rod **10**.

When the center Ch of the through-hole **133** of the contact member **130** coincides with the axis Cs of the piston rod **10** (the lower shaft part **10***c*) at the time of insertion of the piston rod **10** into the masking jig **100**, the inner surface of the cylindrical part **131** evenly contacts the outer surface of the lower shaft part **10***c* of the piston rod **10**.

FIG. **6**A depicts the masking jig **100** of the first embodiment before the piston rod **10** is inserted in it. FIG. **6**B depicts the masking jig **100** of the first embodiment when the piston rod **10** is inserted in it.

As shown in FIG. **6**A, when the center Ch of the through-hole **133** of the contact member **130** and the axis Cs of the piston rod **10** (the lower shaft part **10***c*) are offset from each other at the time of insertion of the piston rod **10** into the masking jig **100**, the outer surface of the lower shaft part **10***c* contacts top faces of only some of the multiple contact pieces **136**, and these contact pieces **136** contacted by the lower shaft part **10***c* receive force in the direction perpendicular to the axial direction. This causes the prevention unit **110** to move in the direction in which these contact pieces **136** receive force from the lower shaft part **10***c*, allowing for easy alignment of the center Ch of the through-hole **133** and the axis Cs of the piston rod **10**. Thus, upon insertion of the piston rod **10** in the masking jig **100**, the multiple contact pieces **136** evenly contact the outer surface of the lower shaft part **10***c*.

By virtue of the multiple contact pieces **136** evenly contacting the outer peripheral end face of the lower shaft part **10***c*, it is possible to more reliably prevent the metal ion Mi from moving toward the male thread **10***e* by going through between the inner surface of the cylindrical part **131** and the outer surface of the lower shaft part **10***c* from above the contact member **130**.

FIG. **7**A depicts a masking jig of a comparative example before the piston rod is inserted into it. FIG. **7**B depicts the masking jig of the comparative example when the piston rod is inserted in it.

The masking jig of the comparative example is different from the masking jig **100** of the first embodiment in that the contact member **130** of the comparative example is not movable in the direction perpendicular to the axis.

When the center Ch of the through-hole **133** of the contact member **130** and the axis Cs of the piston rod **10** (the lower shaft part **10***c*) are offset from each other at the time of insertion of the piston rod **10** into the masking jig **100**, the outer surface of the lower shaft part **10***c* contacts top faces of only some of the multiple contact pieces **136**. The piston rod **10** then moves downward while elastically deforming these some contact pieces **136**. As a result, upon insertion of the piston rod **10** in the masking jig of the comparative example, a gap is formed between the outer surface of the lower shaft part **10***c* and other contact pieces **136** that have not been contacted by the outer surface of the lower shaft part **10***c*. This gap may let the metal ion Mi move toward the male thread **10***e* from above the contact member **130**, which may result in the male thread **10***e* being plated (a metal thin film may be plated on the male thread **10***e*). Further, if only some of the contact pieces **136** are repeatedly deformed due to misalignment between the center Ch of the through-hole **133** and the axis Cs of the piston rod **10** (the lower shaft part **10***c*), it may cause damages to the masking jig, such as plastic deformation of these some contact pieces **136**, leading to a reduced durability of the masking jig.

In contrast, the masking jig **100** of the first embodiment allows for easy alignment of the center Ch of the through-hole **133** of the contact member **130** with the axis Cs of the piston rod **10** (the lower shaft part **10***c*) even when the center Ch of the through-hole **133** and the axis Cs of the piston rod **10** are offset from each other. That is, the prevention unit **110** is supported so as to be movable relative to the support unit **170**, and this allows for easy alignment of the center Ch of the through-hole **133** with the axis Cs of the piston rod **10** after insertion of the piston rod **10**, even when the center Ch of the through-hole **133** and the axis Cs of the piston rod **10** are offset from each other at the time of insertion of the piston rod **10**. As a result, after insertion of the piston rod **10** in the masking jig **100**, the multiple contact pieces **136** evenly contact the outer surface of the lower shaft part **10***c*, and this more reliably prevents the metal ion Mi from moving toward the male thread **10***e* from above the contact member **130**. Hence the masking jig **100** of the first embodiment more reliably prevents plating (formation of a metal thin film) on the to-be-masked part.

In the masking jig **100** of the first embodiment, the inclined part **142** of the prevention member **140** of the prevention unit **110** is inclined such that the gap between the inclined part **142** and the central shaft part **10***a* gradually narrows toward the contact member **130**, and the inclination angle θ relative to the axial direction is less than 45 degrees. The masking jig **100** of the first embodiment thus ensures that the metal ion Mi hardly moves toward the male thread **10***e* from above the contact member **130**, as compared to when the inclination angle θ of the inclined part **142** relative to the axial direction is 45 degrees or more. Hence the masking jig **100** of the first embodiment can more reliably prevent plating on the to-be-masked part.

A smaller angle θ means a lower possibility of the metal ion Mi reaching the lower end of the central shaft part **10***a*, which may result in a failure to form a metal thin film on the lower end of the central shaft part **10***a*. A larger axial length of the inclined part **142** means a lower possibility of the metal ion Mi reaching the lower end of the central shaft part **10***a*. A smaller difference between the diameter of the inner surface of the inclined part **142** and the diameter of the outer surface of the central shaft part **10***a* also means a lower possibility of the metal ion Mi reaching the lower end of the central shaft part **10***a*. In view of this, the angle θ, the axial length of the inclined part **142**, and the difference between the diameters of the inner surface of the inclined part **142** and the outer surface of the central shaft part **10***a* may be set in correlation to each other, such as shortening the axial length of the inclined part **142** with decrease in the angle θ.

In the masking jig **100** of the first embodiment, the slits **135** are formed on the contact member **130**, so that the multiple separate contact pieces **136** do not contact each other in the state where the lower shaft part **10***c* of the piston rod **10** is not inserted. If, on the contrary, the multiple contact pieces **136** are in contact with each other before insertion of the lower shaft part **10***c* of the piston rod **10**, the contact pieces **136** may butt against each other as a result of insertion of the lower shaft part **10***c*. This may cause the contact pieces **136** to contact the central shaft part **10***a*. Such contact of the contact pieces **136** with the central shaft part **10***a* leads to a failure to form a metal thin film on the lower end of the central shaft part **10***a*. As explained above, use of the masking jig **100** of the first embodiment can reliably avoid a failure to plate the part to be plated.

In the masking jig **100** of the first embodiment, the upper outer surface **142***b* of the inclined part **142** of the prevention member **140** of the prevention unit **110** is molded parallel to the axial direction. Also, the size of the inclined part **142** of the prevention member **140** in the direction perpendicular to the axial direction is smaller than that of the base **180** of the support unit **170**. As such, the upper outer surface **142***b* of the inclined part **142** of the prevention member **140** is limited in size in the direction perpendicular to the axial direction. This ensures that the upper outer surface **142***b* of the inclined part **142** of the prevention member **140** hardly interferes with the anode **36** (see FIG. **1**) when the masking jig **100** is installed in the electroplating apparatus **1**. That is, with the inclined part **142** of the prevention member **140** having the aforementioned shape, the masking jig **100** of the first embodiment helps to improve space efficiency in the electroplating apparatus **1**.

In the above embodiment, the inner diameter of the cylindrical part **131** of the contact member **130** of the prevention unit **110** (the hole diameter of the through-hole **133**) is equal to the outer diameter of the lower shaft part **10***c* of the piston rod **10**. The present invention is, however, not limited to this embodiment. The inner diameter of the cylindrical part **131** of the contact member **130** may be different from the outer diameter of the lower shaft part **10***c* of the piston rod **10**. For example, the inner diameter of the cylindrical part **131** of the contact member **130** may be smaller than the outer diameter of the lower shaft part **10***c* of the piston rod **10**. In that case, the contact pieces **136** of the contact member **130** are elastically deformed when the lower shaft part **10***c* of the piston rod **10** is inserted into the through-hole **133**, and with the lower shaft part **10***c* being inserted in the through-hole **133**, the inner surface of the cylindrical part **131** contacts the outer surface of the lower shaft part **10***c*.

The inner diameter of the cylindrical part **131** of the contact member **130** may be larger than the outer diameter of the lower shaft part **10***c* of the piston rod **10**. In that case, namely when there is a gap between the inner surface of the cylindrical part **131** of the contact member **130** and the outer surface of the lower shaft part **10***c* of the piston rod **10**, the inner diameter of the cylindrical part **131** of the contact member **130** and the outer diameter of the lower shaft part **10***c* may be set as follows. When there is a long axial length from the upper end face of the contact member **130** to the male thread **10***e* of the lower shaft part **10***c* of the piston rod **10** inserted in the through-hole **133** of the contact member **130**, the metal ion Mi hardly reaches the male thread **10***e* even with the presence of a gap between the inner surface of the cylindrical part **131** of the contact member **130** and the outer surface of the lower shaft part **10***c* of the piston rod **10**. As such, the position of the male thread **10***e* and the size of the gap may be set in correlation to each other so as to prevent the metal ion Mi from reaching the male thread **10***e*, such as permitting a greater gap between the inner surface of the cylindrical part **131** and the outer surface of the lower shaft part **10***c* of the piston rod **10** with increase in the axial length from the upper end face of the contact member **130** to the male thread **10***e* of the lower shaft part **10***c*.

Alternatively, besides making the inner diameter of the cylindrical part **131** of the contact member **130** larger than the outer diameter of the lower shaft part **10***c* of the piston rod **10**, their axial positions may be defined such that the lower end face of the central shaft part **10***a* of the piston rod **10** abuts and pushes the upper end face of the contact member **130**. As a result of the lower end face of the central shaft part **10***a* of the piston rod **10** pushing the upper end face of the contact member **130**, the contact pieces **136** are elastically deformed to protrude to the inside (to the outer surface of the lower shaft part **10***c*), narrowing the gap between the inner surface of the cylindrical part **131** and the outer surface of the lower shaft part **10***c*. This ensures that the metal ion Mi hardly reaches the male thread **10***e*, even with the presence of the gap between the inner surface of the cylindrical part **131** of the contact member **130** and the outer surface of the lower shaft part **10***c* of the piston rod **10**.

Second Embodiment

FIG. **8** depicts a schematic configuration of a masking jig **200** of the second embodiment.

The masking jig **200** of the second embodiment is different from the masking jig **100** of the first embodiment in that a base **280** of a support unit **270** of the masking jig **200** includes, on its bottom, a blocking part **283** that blocks the metal ion Mi from moving to the inside of the support unit **270** from outside thereof. Below a description will be particularly given of the difference from the masking jig **100** of the first embodiment. The components with the shapes and functions common to the masking jig **100** of the first embodiment and the masking jig **200** of the second embodiment are denoted by the same reference numerals, and detailed description thereof will be omitted.

The masking jig **200** of the second embodiment includes the prevention unit **110** and the support unit **270**. The prevention unit **110** prevents the metal ion Mi from moving toward the male thread **10***e* on the lower shaft part **10***c* of the piston rod **10**. The support unit **270** supports the prevention unit **110**.

The support unit **270** includes the base **280** on which the prevention unit **110** rests. The base **280** includes a cylindrical part **282** and the blocking part **283** at the bottom of the cylindrical part **282**. The blocking part **283** blocks the metal ion Mi from moving toward the male thread **10***e* of the piston rod **10**.

The blocking part **283** is a disk-like part closing the lower opening of the cylindrical part **282**.

For example, the blocking part **283** is adhered, tacked or welded to the lower end of the cylindrical part **282**. Alternatively, the blocking part **283** may be interference-fitted to the inside of the cylindrical part **282**. Still alternatively, the cylindrical part **282** and the blocking part **283** may be integrally formed; in other words, the base **280** may have a cup shape.

In the masking jig **200** of the second embodiment, the cylindrical part **282** and the blocking part **283** of the base **280** of the support unit **270** surround the male thread **10***e*. This more reliably prevents the metal ion Mi from moving toward the male thread **10***e*, as compared to when the blocking part **283** is not provided. In other words, the masking jig **200** of the second embodiment more reliably prevents plating on the to-be-masked part.

Third Embodiment

FIG. **9**A depicts a schematic configuration of a masking jig **300** of the third embodiment. FIG. **9**B depicts the masking jig **300** of the third embodiment when the piston rod **10** is inserted in it.

The masking jig **300** of the third embodiment is different from the masking jig **100** of the first embodiment in regard to the prevention unit **110**. Below a description will be particularly given of the difference from the masking jig **100** of the first embodiment. The components with the shapes and functions common to the masking jig **100** of the first embodiment and the masking jig **300** of the third embodiment are denoted by the same reference numerals, and detailed description thereof will be omitted.

The masking jig **300** of the third embodiment includes a prevention unit **310** and the support unit **170**. The prevention unit **310** prevents the metal ion Mi from moving toward the male thread **10***e* on the lower shaft part **10***c* of the piston rod **10**. The support unit **170** supports the prevention unit **310**.

Besides the contact member **130**, the prevention member **140** and the holding member **150** included in the prevention unit **110** of the first embodiment, the prevention unit **310** includes an elastic member **360** that allows the contact member **130** to move in the axial direction. The elastic member **360** is positioned between the flange **132** of the contact member **130** and the disk part **151** of the holding member **150**.

For example, the elastic member **360** may be a round and planar member molded of rubber and including a through-hole **361** at the center thereof. Alternatively, the elastic member **360** may be a coil spring.

The masking jig **300** of the third embodiment can have an axial displacement of the piston rod **10** absorbed by the prevention unit **310** more effectively than the masking jig **100** of the first embodiment. More specifically, for example even when an axial position of the piston rod **10** held by the holding mechanism **20** is below a standard position (e.g., the position shown in FIG. **5**), the elastic member **360** is elastically deformed to allow the contact member **130** to move downward. This prevents damage to the deformation part **134** of the contact member **130** due to contact of the lower end face of the central shaft part **10***a* with the contact member **130**, helping to improve durability.

Fourth Embodiment

FIGS. **10**A and **10**B depict a schematic configuration of a masking jig **400** of the fourth embodiment.

The masking jig **400** of the fourth embodiment is different from the masking jig **100** of the first embodiment in regard to the shape of the contact member **130** of the prevention unit **110**. Below a description will be particularly given of the difference from the masking jig **100** of the first embodiment. The components with the shapes and functions common to the masking jig **100** of the first embodiment and the masking jig **400** of the fourth embodiment are denoted by the same reference numerals, and detailed description thereof will be omitted.

The masking jig **400** of the fourth embodiment includes a prevention unit **410** and the support unit **170**. The prevention unit **410** prevents the metal ion Mi from moving toward the male thread **10***e* on the lower shaft part **10***c* of the piston rod **10**. The support unit **170** supports the prevention unit **410**.

The prevention unit **410** includes a contact member **430** that contacts the outer surface of the lower shaft part **10***c* of the piston rod **10** to prevent the metal ion Mi from moving toward the male thread **10***e*. The contact member **430** is a round and planar member including a through-hole **433** at the center thereof. In other words, the contact member **430** of the fourth embodiment does not surround the male thread **10***e* of the piston rod **10**, unlike the contact member **130** of the first embodiment. Around the through-hole **433**, the contact member **430** includes a deformation part **434** elastically deformed by insertion of the male thread **10***e* into the through-hole **433** and contacting the outer surface of the piston rod **10**. The deformation part **434** includes radial slits **435** dividing the deformation part **434** into multiple sections. That is, the contact member **430** includes multiple separate contact pieces **436**, and the slits **435** are formed so that the contact pieces **436** do not contact each other in a state where the lower shaft part **10***c* of the piston rod **10** is not inserted.

For example, the contact member **430** is made of resin, such as polyvinylidene fluoride (PVDF), or metal.

Compared to the masking jig **100** of the first embodiment, the masking jig **400** of the fourth embodiment may let the metal ion Mi more easily move toward the male thread **10***e* from below the male thread **10***e* of the piston rod **10**. However, as long as the base **180** has a sufficient axial length below the male thread **10***e*, it can be ensured that the metal ion Mi does not reach the male thread **10***e*. Thus, use of the prevention unit **410**, which is not provided with the part to surround the male thread **10***e* of the piston rod **10**, allows to simplify the shape of the masking jig, like the masking jig **400** of the forth embodiment.

The contact member **430** may consist of multiple round and planar members stacked in the axial direction. In other words, the contact member **430** may consist of multiple layers stacked in the axial direction.

Also, the elastic member **360** of the third embodiment may be placed between the contact member **430** and the disk part **151** of the holding member **150**.

Fifth Embodiment

FIG. **11** depicts a schematic configuration of a masking jig **500** of the fifth embodiment.

The masking jig **500** of the fifth embodiment is different from the masking jig **100** of the first embodiment in regard to the prevention unit **110**. Below a description will be particularly given of the difference from the masking jig **100** of the first embodiment. The components with the shapes and functions common to the masking jig **100** of the first embodiment and the masking jig **500** of the fifth embodiment are denoted by the same reference numerals, and detailed description thereof will be omitted.

The masking jig **500** of the fifth embodiment includes a prevention unit **510** and the support unit **170**. The prevention unit **510** prevents the metal ion Mi from moving toward the male thread **10***e* on the lower shaft part **10***c* of the piston rod **10**. The support unit **170** supports the prevention unit **510**.

Besides the contact member **130**, the prevention member **140** and the holding member **150** included in the prevention unit **110** of the first embodiment, the prevention unit **510** includes a blocking member **520** above the contact member **130**.

The blocking member **520** is a round and planer member including a through-hole **521** at the center thereof. The hole diameter of the through-hole **521** is smaller than the outer diameter of the lower shaft part **10***c* of the piston rod **10**. The blocking member **520** is an elastic body, such as rubber. For example, the blocking member **520** is molded of thermoplastic fluoropolymer, such as polyvinylidene fluoride (PVDF).

In the masking jig **500** of the fifth embodiment, the hole diameter of the through-hole **521** of the blocking member **520** is smaller than the outer diameter of the lower shaft part **10***c* of the piston rod **10**. This means that the blocking member **520** contacts the outer surface of the lower shaft part **10***c* of the piston rod **10** when the lower shaft part **10***c* of the piston rod **10** is inserted in the through-hole **521**. The blocking member **520** thus blocks the metal ion Mi from moving toward the male thread **10***e* from above the blocking member **520**. This more reliably prevents formation of a metal thin film (reductive deposition of metal) on the male thread **10***e* of the piston rod **10**.

REFERENCE SIGNS LIST

1 Electroplating apparatus
10 Piston rod
10*c* Lower shaft part
10*e* Male thread
100, **200**, **300**, **400**, **500** Masking jig
110, **310**, **410**, **510** Prevention unit
130 Contact member
140 Prevention member
150 Holding member
170, **270** Support unit
180, **280** Base
190 Restricting member
195 Lock nut

The invention claimed is:

1. A masking jig comprising:

a prevention unit including a contact member, the contact member including a through-hole and a deformation part around the through-hole, the through-hole allowing for insertion of a rod-like member to be plated, the deformation part being configured to get elastically deformed by insertion of a specific portion of the member to be plated into the through-hole and contact an outer peripheral end face of the member to be plated, the prevention unit being configured to prevent a plating substance from moving toward the specific portion; and

a support part configured to support the prevention unit such that the prevention unit moves in a direction intersecting an axial direction of the member to be plated, wherein

the support part includes a base and a restricting member, the base allowing the contact member to rest thereon, the restricting member holding the prevention unit between the base and the restricting member to thereby restrict the prevention unit from moving in the axial direction, and

the support part has a gap between an inner surface of the restricting member and an outer surface of the prevention unit, the gap allowing the prevention unit to move relative to the base in the direction intersecting the axial direction until the outer surface of the prevention unit contacts the inner surface of the restricting member.

2. The masking jig according to claim **1**, wherein the deformation part includes radial slits, the radial slits dividing the deformation part into a plurality of sections.

3. The masking jig according to claim **2**, wherein

the contact member is an elastic body, and

the contact member is formed of a plurality of layers stacked in the axial direction of the member to be plated.

4. The masking jig according to claim **3**, wherein the prevention unit further includes a prevention member configured to prevent a plating substance from moving toward the specific portion.

5. The masking jig according to claim **2**, wherein the prevention unit further includes a prevention member configured to prevent a plating substance from moving toward the specific portion.

6. The masking jig according to claim **5**, wherein

the prevention member includes an inclined part, the inclined part being inclined relative to the axial direction of the member to be plated such that a gap between the inclined part and a given portion of the member to be plated gradually narrows toward the contact member, and

an inclination angle of the inclined part relative to the axial direction is less than 45 degrees.

7. The masking jig according to claim **6**, wherein

the inclined part of the prevention member is smaller in size in the direction intersecting the axial direction than the base.

8. The masking jig according to claim 7, wherein

the base includes a blocking part configured to block the plating substance from moving toward the specific portion.

9. The masking jig according to claim 8, wherein

the prevention member includes an inclined part, the inclined part being inclined relative to the axial direction of the member to be plated such that a gap between the inclined part and a given portion of the member to be plated gradually narrows toward the contact member, and

an inclination angle of the inclined part relative to the axial direction is less than 45 degrees.

10. The masking jig according to claim 9, wherein

the base includes a blocking part configured to block the plating substance from moving toward the specific portion.

11. The masking jig according to claim 6, wherein

the base includes a blocking part configured to block the plating substance from moving toward the specific portion.

12. The masking jig according to claim 1, wherein

the contact member is an elastic body, and

the contact member is formed of a plurality of layers stacked in the axial direction of the member to be plated.

13. The masking jig according to claim 12, wherein the prevention unit further includes a prevention member configured to prevent a plating substance from moving toward the specific portion.

14. The masking jig according to claim 13, wherein

the inclined part of the prevention member is smaller in size in the direction intersecting the axial direction than the base.

15. The masking jig according to claim 1, wherein the prevention unit further includes a prevention member configured to prevent a plating substance from moving toward the specific portion.

16. The masking jig according to claim 15, wherein

the prevention member includes an inclined part, the inclined part being inclined relative to the axial direction of the member to be plated such that a gap between the inclined part and a given portion of the member to be plated gradually narrows toward the contact member, and

an inclination angle of the inclined part relative to the axial direction is less than 45 degrees.

17. The masking jig according to claim 16, wherein

the inclined part of the prevention member is smaller in size in the direction intersecting the axial direction than the base.

18. The masking jig according to claim 17, wherein

the base includes a blocking part configured to block the plating substance from moving toward the specific portion.

19. The masking jig according to claim 16, wherein

the base includes a blocking part configured to block the plating substance from moving toward the specific portion.

20. An electroplating apparatus comprising:

a plating tank storing a plating solution containing a plating substance;

a holding part configured to hold a rod-like member to be plated; and

a masking jig placed within the plating tank, the masking jig being configured to mask a specific portion of the member to be plated, wherein

the masking jig includes:

a prevention unit including a contact member, the contact member including a through-hole and a deformation part around the through-hole, the through-hole allowing for insertion of the member to be plated, the deformation part being configured to get elastically deformed by insertion of the specific portion into the through-hole and contact an outer peripheral end face of the member to be plated, the prevention unit being configured to prevent a plating substance from moving toward the specific portion; and

a support part configured to support the prevention unit such that the prevention unit moves in a direction intersecting an axial direction of the member to be plated,

the support part includes a base and a restricting member, the base allowing the contact member to rest thereon, the restricting member holding the prevention unit between the base and the restricting member to thereby restrict the prevention unit from moving in the axial direction, and

the support part has a gap between an inner surface of the restricting member and an outer surface of the prevention unit, the gap allowing the prevention unit to move relative to the base in the direction intersecting the axial direction until the outer surface of the prevention unit contacts the inner surface of the restricting member.

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